Ocean Surface Layer Drift Revealed by Satellite Data

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Historically, from low earth orbits, ocean surface feature tracking analyses have been based on data from a single orbital sensor collected over the revisit interval of a single satellite. In this paper, we report the first time that ocean surface layer currents have been derived by performing feature tracking using data from different sensors on different satellites. Satellite ocean color data provide important insight into the marine biosphere by quantifying certain fundamental properties (e.g. phytoplankton pigment concentration, marine primary production) on a global scale. In addition, satellite ocean color data can also be used as a tracer for measuring ocean surface layer currents, because the ocean color signal comprises information from a deeper water depth (10 to 30 meters) than surface signatures (such as sea surface temperature).

At present, there are two major global ocean color sensors in orbit. The Sea-viewing Wide Field-of-View Scanner (SeaWiFS) was launched onboard the Orbview-2 satellite in August 1997 [McClain et al., 1998], and the Moderate Resolution Imaging Spectroradiometer (MODIS) was launched onboard the Terra (EOS AM-1) satellite on December 18, 1999. Both satellites are in polar orbits at 705 kilometer altitudes, and each sensor views greater than 90% of the Earth's surface in 1-2 days. SeaWiFS acquires data in 8 visible and near-infrared bands, and MODIS acquires data in 36 spectral bands (UV-VIS-IR). Several of the MODIS visual wavelength bands are analogous to the SeaWiFS ocean color bands. These data will provide important new information on the interactions between earth's major climate components and improve our understanding of global physical and biological processes on the land, in the oceans, and in the lower atmosphere [Esaias et al., 1998].

On a daily basis, the global observations of MODIS and SeaWiFS overlap to a large degree, with MODIS currently preceding SeaWiFS by about 70 minutes. The availability of multiple ocean color sensors in orbit allows the production of new data products. One such product, surface layer drift, can be derived when two satellite tracks overlap within a short time (for example, a few hours) without cloud coverage.

In this note, we demonstrate how chlorophyll *a* concentration images provided by MODIS and SeaWiFS can be used to derive surface layer drift. Data from MODIS and SeaWiFS (Figure 1) were collected on May 8, 2000 at 15:45 and 16:52 GMT, respectively, off the east coast of the United States. Major oceanographic features, such as the Gulf Stream boundary and a large cold-core eddy south of the Gulf Stream, can be clearly identified. To validate the results, data from several drifter buoys are compared with the satellite-derived flow field. The qualitative comparison shows a generally consistent pattern.

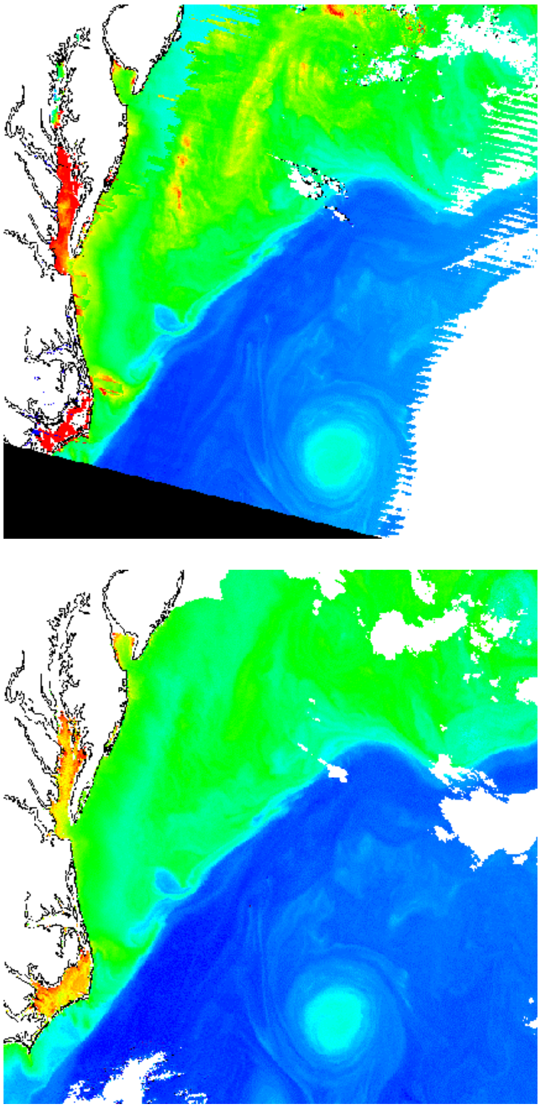

Fig. 1. Chlorophyll-a concentration data collected over US east coast from (a) MODIS, and (b) SeaWiFS on May 8, 2000 separated by 67 minutes.

Comparison of MODIS and SeaWiFS Data

Currently, the comparison between SeaWiFS and MODIS is made with no correction for advection-induced change of chlorophyll values at different times, and is simply a pixel-pixel comparison. Advection between ocean color feature locations will add to the root-mean-square (RMS) errors, especially in high gradient regions. The satellite-derived current field can be used to assess the impact of changing chlorophyll values. Using the derived initial and end pixel numbers of the tracked features or the drift vector, the chlorophyll values at the original and end locations can be compared.

Figure 3 shows the comparison of chlorophyll *a* concentration data from MODIS and SeaWiFS (a) at the same locations, and (b) at the advected locations using the center pixel of a 17 x 17 km box surrounding the vector location. The RMS difference in chlorophyll concentration between these versions of MODIS and SeaWiFS chlorophyll products are 1.0124 mg/m^3 (or 0.1415 in log value) and 0.9701 mg/m^3 (or 0.1358 in log value) at the same locations and at the advected locations, respectively. The linear fit is somewhat improved after including the effects of advection. A reduction of 4 % in RMS error is attributed to correction for surface layer drift which can be derived from satellites. If a simple regression is used to eliminate the bias, the reduction of RMS difference is increased to 6.3%. Most of the points of improvement are at the locations where SeaWiFS predicts higher chlorophyll than the preliminary MODIS algorithm used here. This implies that the low chlorophyll concentration areas near the Gulf Stream were moved into the relatively high concentration locations. Although the improvement is small, it is in the expected direction, and the comparison demonstrates the general first-order accuracy of the drift field derived from satellite data. This comparison also indicates that surface layer drift is generally tangential to chlorophyll concentration gradient, allowing a steady gradient to be maintained. Once advection effects are well constrained, additional nonlinear effects such as biological growth/decay and diffusion processes can be targeted for further investigations.